2015　Research project entrusted by Ministry of the Environment, Japan

2015　Research report on marine debris floating on the ocean surface in Setonaikai

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NAIGAI MAP PRODUCTION Inc.

Contents

Chapter I　Survey Outline

I.1.　Purpose of survey

In the 2014 Research report on marine debris floating on the ocean surface and settled on the sea bed in coastal areas around Japan (“2014 Research in coastal areas” hereinafter), a field survey of floating debris in the Setonaikai was conducted in winter (February and March). Following that, at the investigative meeting on the 2014 Research in coastal areas, the committee members advised that it would be better to conduct a survey in summer as well in addition to conducting a survey in winter only in view of the big variation in the total volume of floating debris depending on the season.

In response to that advice, in this project, a survey was conducted in autumn mainly in the sea areas where a field survey of floating debris was conducted in the “2014 Research in coastal areas” (because there was not enough time to conduct a survey in summer). A decision was made to conduct the survey in order to understand the actual state of floating debris in the Setonaikai that takes seasonal changes into consideration while making a comparison with the results of the survey on floating debris that was conducted in the “2014 Research in coastal areas”.

I.2.　Survey Period

October 5, 2014- October 17, 2015

I.3.　Composition of this survey

This survey is composed of the following 2 items of I.3.1 and I.3.2. The flow of this survey is displayed in diagram I.4-1 and the survey process is displayed in chart I.5-1.

I.3.1　Field Survey regarding floatingwater debris

A visual survey of large floating debris and a sampling survey of Micro-Plastics were conducted with the sea areas where a field survey of floating debris was conducted in the “2014 Research in coastal areas” as the target.

(1)　Selection of sea areas where the survey will be conducted

Six sea areas where the survey will be conducted were selected from the sea areas where a field survey on floating debris was conducted in the “2014 Research in coastal areas” after discussing with the officers in charge from the Ministry of the Environment.

(2) Conducting of the survey

In each of the survey areas (sea areas for survey) selected in (1), measurements of floating debris (about 2 days in each area) were conducted through observation from ships. At this time the accurate locations of floating debris were obtained using GPS etc. For micro plastics, which are difficult to measure with the eye, neuston nets were used to the conduct survey. Other specific measurement methods were decided based on opinions stated in this investigative meeting.

The survey methods were decided based on the methods utilized in the “2014 Research in coastal areas” and the 2014 Research report on marine debris floating on the ocean surface and settled on the sea bed in offshore areas around Japan （“2014 Research in offshore areas” hereinafter） after discussing with the officers in charge from the Ministry of the Environment.

(3) Assessment of results

The data obtained above (2) was organized in the following way.

・Estimation of the total volume (including composition) and density of floating debris in autumn in the Setonaikai.

・Characteristics of the floating debris in these sea areas (sorting out uneven distribution in different areas. Making comparisons with the volume and composition etc. in the “2014 Research in coastal areas”. Studying variation due to floods/by season)

・Study of the source (including the amount and type of debris generated) based on information collected in (2) and information such as the ocean current of the sea area, the tidal current and amount of inflow from rivers.

I.3.2 Current state analysis regarding floating/underwater debris and the sorting of tasks

Based on the survey results above in (1) and reports of the “2014 Research in coastal areas” and the “2014 Research in offshore areas”, from the perspective of locality (whether it is the problem of a restricted area), diversity of related entities (whether it is the problem of a restricted entity), seasonal changes etc., the current state of the floating debris problem in the Setonaikai was analyzed and the issues etc., were organized.

I.4. Flow of survey

The flow of survey is displayed in diagram 1.4-1.

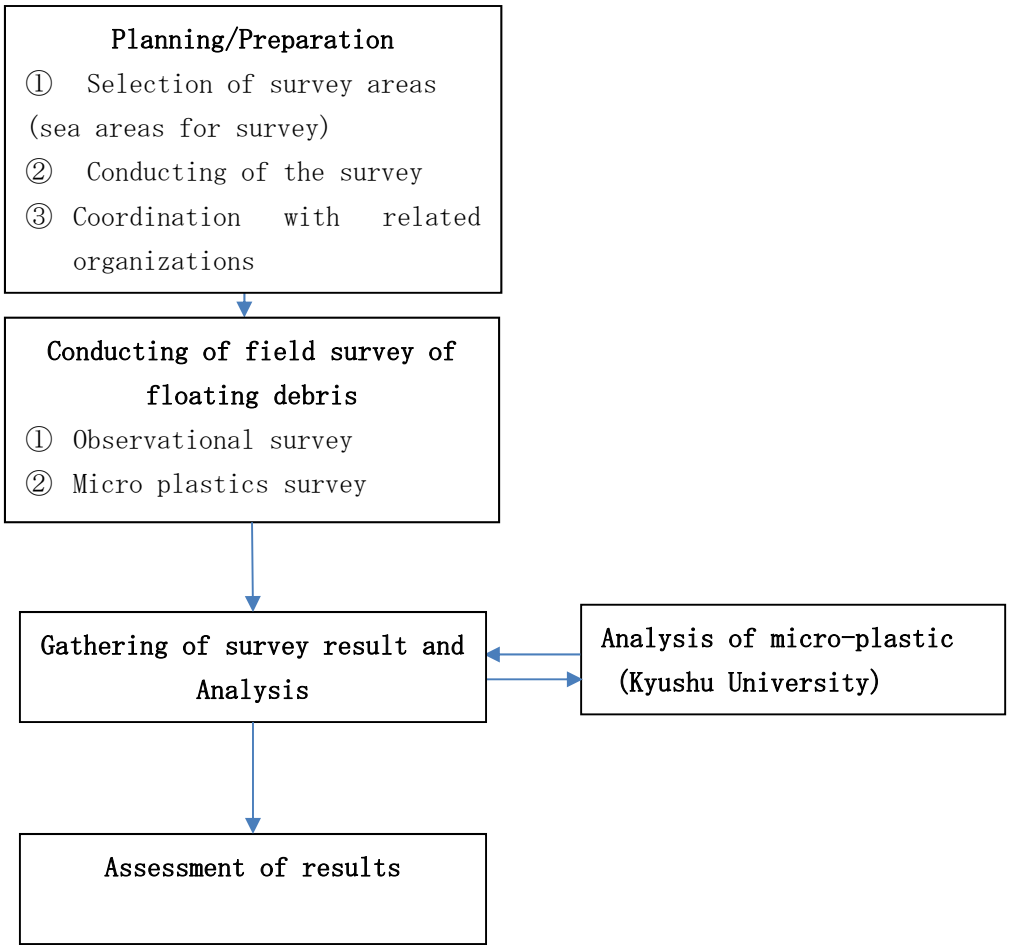


diagram I.4-1 Flow of survey

I.5. Survey process

The survey process is displayed in chart 1.5-1.

chart I.5-1 Survey process

	2015				2016		
Process	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
Planning/Preparation	———						
Field survey		———					
Analysis of micro-plastic			———	———			
Summary of survey result and Analysis			———	———	———		
Assessment of results					———	———	

Chapter II　Field Survey Regarding Floating Debris

II.1.1　Survey method

II.1.1　Selection of survey area

In the selection of the target sea areas for conducting the survey, the 6 sea areas below were selected from the sea areas where a field survey of floating debris was conducted in the “2014 Research in coastal areas”.

・Harima Sea(south)
・Hiuchi Sea(north)
・Mizushima Sea
・Bingo Sea
・Harima Sea(south)
・Osaka Bay

Harima Sea North (Higashifutami Fisheries Cooperative)—where a field survey of floating debris was conducted in the “2014 Research in coastal areas”—was excluded from this survey because the same kind of survey had been conducted by Tokyo University of Marine Science and Technology in the surrounding sea area in the autumn of 2014.

II.1.2　Coordination with related organizations

In this survey, coordination was carried out with the cooperating organizations below.

・Fishery cooperatives in each sea area
　Making arrangements for fishing vessels to be used in the survey, request for handling liaison with the ship captain, providing local information of each area, etc.
・Japan Coast Guard (5^{th} district and 6^{th} district)
　Official sanction for conducting operations on the sea
・Research Institute for Applied Mechanics, Kyushu University
　Request for analysis of Micro-Plastics samples

II.1.3　Survey methods

A survey was conducted using the methods shown below in accordance with the survey methods adopted in the “2014 Research in coastal areas” and the “2014 Research in offshore areas”.

1) Outline of the survey implementation

The image of the survey is displayed in Diagram II.1-1.

- Generally there were 2 survey lines for 1 day, and the survey time for 1 line was about 1.5 hours.
- 1 line veered about every 0.5 hours, and vessels ran in a zigzag manner.
- Veering was roughly expected to be at 45-degree angles. * Example: North (0°) →Northeast (45°)→North (0°).
- The ship speed was about 5 knots (approx. 9km/h/ 2.5m/s), veered every 4.5km, and ran 13.5km per 1 line.
- The actual survey line was recorded using a handy GPS device (recorded with track mode on).

The collecting of micro plastics was conducted once.

However, in the event that a survey of the scheduled line cannot be conducted due to the weather or the conditions of the sea area where fishing gear has been set up, a survey of the planned distance using an alternative line will be conducted as far as possible and a flexible response will be made based on discussion of the details with the ship captain.

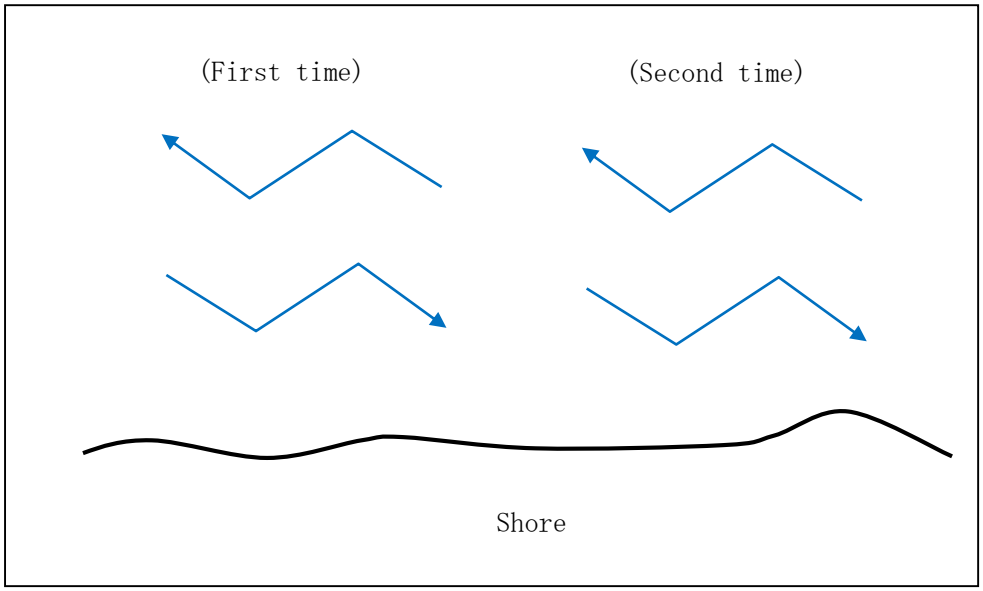


Diagram II.1-1 The image of floating debris field survey

2) Observation system

・A total of 4 observers (primary and secondary) were allocated with 2 people in one group, and one group each on the port and the starboard side of the ship.

The primary observer is responsible for making observations and taking records.
The secondary observer is responsible for providing assistance in observations (improving the rate of discovering floating debris), recording GPS etc., coordinating with the ship captain, deciding on the sea route and giving reminders to ensure safety on board the ship.

・The main equipment used during observation are as follows.
Log books, writing tools, working clothes, boots, life jackets, hats, polarized sunglasses, and binocular glasses.

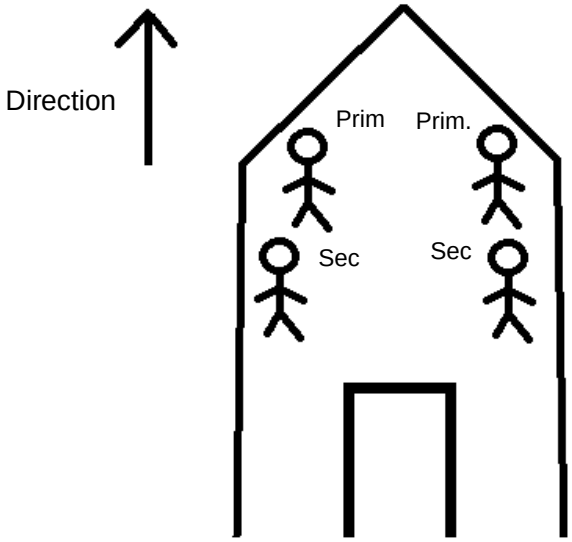


Diagram II.1-2　Placement of investigator（Image）

Picture II.1-3（left）Picture II.1-4（right）　The condition of survey

3) Procedure

The basic time schedule is as shown below.

Process	Details
Confirmation the day before	Conditions on the sea will be analyzed to decide whether to conduct the survey on the following day. A decision on whether to conduct the survey will be made based on information collected of weather forecasts among other things and discussions with the fishery cooperative.
On the actual day ↓	
(Before boarding the ship) Preparations, on-site meetings	・Confirmation of observation conditions (wind speed, sea conditions, etc.) ・Preparations of survey equipment and other things. ・Greetings and meetings with ship captain and fishery cooperative personnel.
↓	
(While on the ship) Survey on the sea	The survey below will be conducted using the line that has been planned in advance ・Observation of floating debris ・Sampling of Micro-Plastics
↓	
(After disembarkation) Tidying up etc.	・Cleaning of equipment ・Payment to the fishery cooperative for use of the ship (final day)

4) Observation method

Observations were conducted using the following procedure.

・Floating debris are discovered by carefully watching the area in front within a scope of 0 to 60 degrees.

The primary observer will describe the floating debris that are discovered in the log book. (Refer to the next page for details of how descriptions are written).

The information recorded in the log book will be stored by promptly converting it into electronic data (Excel) after the survey ends.

The secondary observer will carefully watch the area in front in the same way as the primary observer to help the primary observer avoid missing out anything, which will improve the rate of discovering floating debris. The primary and secondary observers will work together to observe the area, and particularly during the time when the primary observer is recording things in the log book, the secondary observer will continue to observe the area.

・If floating debris with special characteristics are discovered, the ship will stop, and if there are too many floating debris to be recorded in time, the ship will sail at a reduced speed temporarily. An appropriate response will be made by communicating with the ship captain.

5) Method for visual survey

The floating debris that were observed were categorized according to the categories shown in the chart below and entered into the log book. The categorization method is the same as the one taught by Assistant Professor Uchida (Tokyo University of Marine Science and Technology), and the tools to be used during observation that he provided were also used with slight modification. Among the items to be recorded in the log book, the items below were recorded based on the following rules.

・Number

If several pieces of floating debris are discovered simultaneously, each item will be recorded separately as far as possible, and if several pieces are discovered as a group, they will be recorded as a group, and the individual floating debris that make up the group will also be recorded. However, if the items cannot be counted due to a rip current or some other reason, they will be recorded as “many” without counting the quantity.

・Size

Since there are differences in visual observation between individuals, the criteria are unified using the quick reference chart (Diagram II.1-7) which serves as a yardstick. In cases where there is uncertainty, the primary and secondary observers will discuss with each other and try their best to standardize the description as far as possible.

・Nearest distance

The distance of floating debris when they come to the side of the ship is recorded at intervals of 5 m. Since there are differences in visual observation between individuals, the observer’s eye level and the angle of the floating object are recorded, and the distance is determined from the height of the ship’s body that has been measured in advance based on a formula (refer to Diagrams II.1-8 and 9).

Chart II.1-5 Categories of floating debris discovered

Symbol	Floating debris
FGN	Fishing Gear Net
FGF	Fishing Gear Float
FGO	Fishing Gear Other
EP	Expanded Polystyrene
V	Vinyl
PB	Plastic Bottle
PC	Petrochemical
G	Glass goods
MG	Metal Goods
W	wood
UO	Unnatulal other
SW	Seaweed
DW	Driftwood
NO	Natulal other
UK	Unknown

漂流物　目視観察野帳							通し番号：(　　　)
日付　　　月　　　日	開始時刻　　：			終了時刻　　：		天候	
記録者	開始位置			終了位置		風向・風速	度　　m/s
記録場所　左舷／右舷	緯度：　-　-			緯度：　-　-		海況	
コース・速力　　／	経度：　-　-			経度：　-　-		グレア率	%
種類および材質など	色	数	サイズ	最接近距離m	発見時刻	発見者	備考
流藻　流木(枝)　プラ片	茶、白		SS、S、M、L、LL		：　：		
流藻　流木(枝)　プラ片	茶、白		SS、S、M、L、LL		：　：		
流藻　流木(枝)　プラ片	茶、白		SS、S、M、L、LL		：　：		
流藻　流木(枝)　プラ片	茶、白		SS、S、M、L、LL		：　：		
流藻　流木(枝)　プラ片	茶、白		SS、S、M、L、LL		：　：		
流藻　流木(枝)　プラ片	茶、白		SS、S、M、L、LL		：　：		
流藻　流木(枝)　プラ片	茶、白		SS、S、M、L、LL		：　：		
流藻　流木(枝)　プラ片	茶、白		SS、S、M、L、LL		：　：		
流藻　流木(枝)　プラ片	茶、白		SS、S、M、L、LL		：　：		
流藻　流木(枝)　プラ片	茶、白		SS、S、M、L、LL		：　：		
流藻　流木(枝)　プラ片	茶、白		SS、S、M、L、LL		：　：		
流藻　流木(枝)　プラ片	茶、白		SS、S、M、L、LL		：　：		
流藻　流木(枝)　プラ片	茶、白		SS、S、M、L、LL		：　：		
流藻　流木(枝)　プラ片	茶、白		SS、S、M、L、LL		：　：		
流藻　流木(枝)　プラ片	茶、白		SS、S、M、L、LL		：　：		

Diagram II.1-6　　Log book for observation

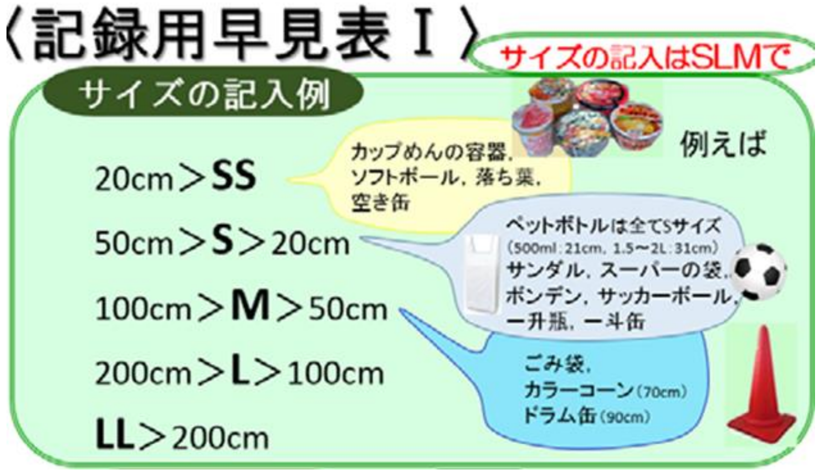


Diagram II.1-7　　The quick reference chart for size

height	angle	distance	height	angle	distance	height	angle	distance	height	angle	distance
1	0	0	2	0	0	3	0	0	4	0	0
	5	0.1		5	0.2		5	0.3		5	0.3
	10	0.2		10	0.4		10	0.5		10	0.7
	15	0.3		15	0.5		15	0.8		15	1.1
	20	0.4		20	0.7		20	1.1		20	1.5
	25	0.5		25	0.9		25	1.4		25	1.9
	30	0.6		30	1.2		30	1.7		30	2.3
	35	0.7		35	1.4		35	2.1		35	2.8
	40	0.8		40	1.7		40	2.5		40	3.4
	45	1		45	2		45	3		45	4
	50	1.2		50	2.4		50	3.6		50	4.8
	55	1.4		55	2.9		55	4.3		55	5.7
	60	1.7		60	3.5		60	5.2		60	6.9
	65	2.1		65	4.3		65	6.4		65	8.6
	70	2.7		70	5.5		70	8.2		70	11
	75	3.7		75	7.5		75	11.2		75	14.9
	80	5.7		80	11.3		80	17		80	22.7
	85	11.4		85	22.9		85	34.3		85	45.7
	86	14.3		86	28.6		86	42.9		86	57.2
	87	19.1		87	38.2		87	57.2		87	76.3
	88	28.6		88	57.3		88	85.9		88	114.5
	89	57.3		89	114.6		89	171.9		89	229.2
	90	0		90	0		90	0		90	0

height	angle	distance	height	angle	distance	height	angle	distance	height	angle	distance
5	0	0	6	0	0	7	0	0	8	0	0
	5	0.4		5	0.5		5	0.6		5	0.7
	10	0.9		10	1.1		10	1.2		10	1.4
	15	1.3		15	1.6		15	1.9		15	2.1
	20	1.8		20	2.2		20	2.5		20	2.9
	25	2.3		25	2.8		25	3.3		25	3.7
	30	2.9		30	3.5		30	4		30	4.6
	35	3.5		35	4.2		35	4.9		35	5.6
	40	4.2		40	5		40	5.9		40	6.7

Diagram II.1-8 The quick reference chart for nearest distance

(Estimating a distance from a combination of angle and height of eyes)

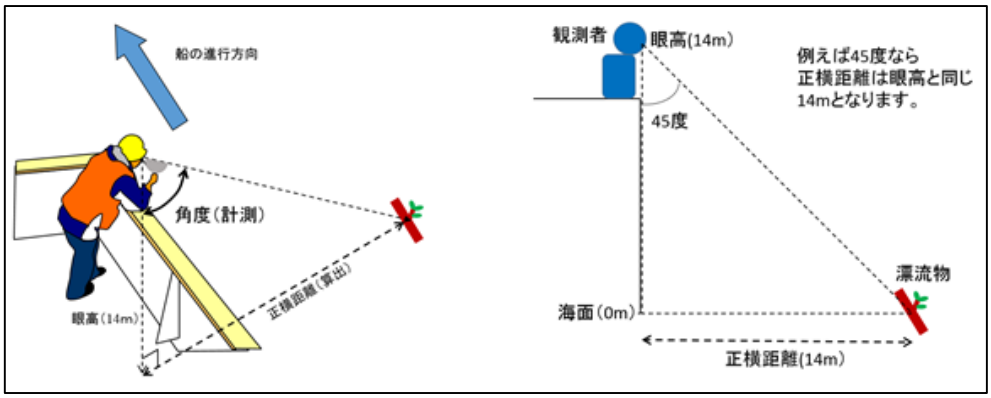


Diagram II.1-9 Recording method for nearest distance

6) Summary of survey result

The line transect method was used in accordance with the “2014 Research on offshore areas”.

The tabulation method and results will be described later.

7) Micro plastics survey

The micro plastics survey was conducted in the following way based on the “2014 Research in offshore areas”.

（1）Collecting

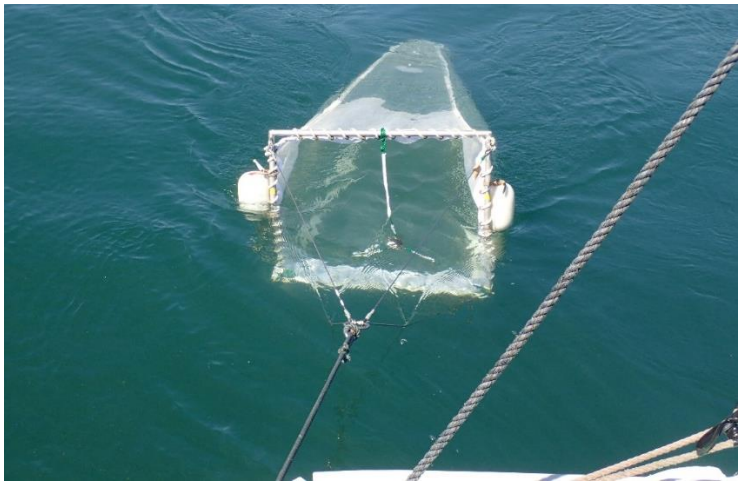
- Debris was collected using a Neuston net with a flow meter (Meteorological Agency (JMA) Neuston net No. 5552: Diameter, 75cm edge; length 300cm; knit nip, mesh size 350μm).
- The amount of filtered water was calculated using the “offshore survey” method.
- As a general rule trawling were conducted at 2 knots for 20 minutes.
- The collected samples were stored by placing them in a solution containing more than 2% formalin.

（2）Analysis

- Professor Atsuhiko Isobe (Research Institute for Applied Mechanics, Kyushu University) was asked to analyze the collected samples.

（3）Gathering of survey result

The floating density (individual floating numbers per unit area) was determined from the filtered water amount and the individual numbers obtained from calculations according to survey areas (sea areas for survey).



Picture II.1-10 Micro-Plastics Collecting

II.2. Survey implementation

II.2.1 Summary of survey

The schedule and areas where the survey was conducted are shown in Chart II.2-1 and Diagram II.2-1. Furthermore, the lines that were implemented in the survey are shown in Diagrams II.2-2 to 7.

The special items of note are as follows.

- Survey of the Harima Sea (south) was postponed by 1 day due to inclement weather.
- 4 lines a day were launched only for Bingo Sea (south) based on consideration of the weather on the actual day and the proficiency level of the operations.

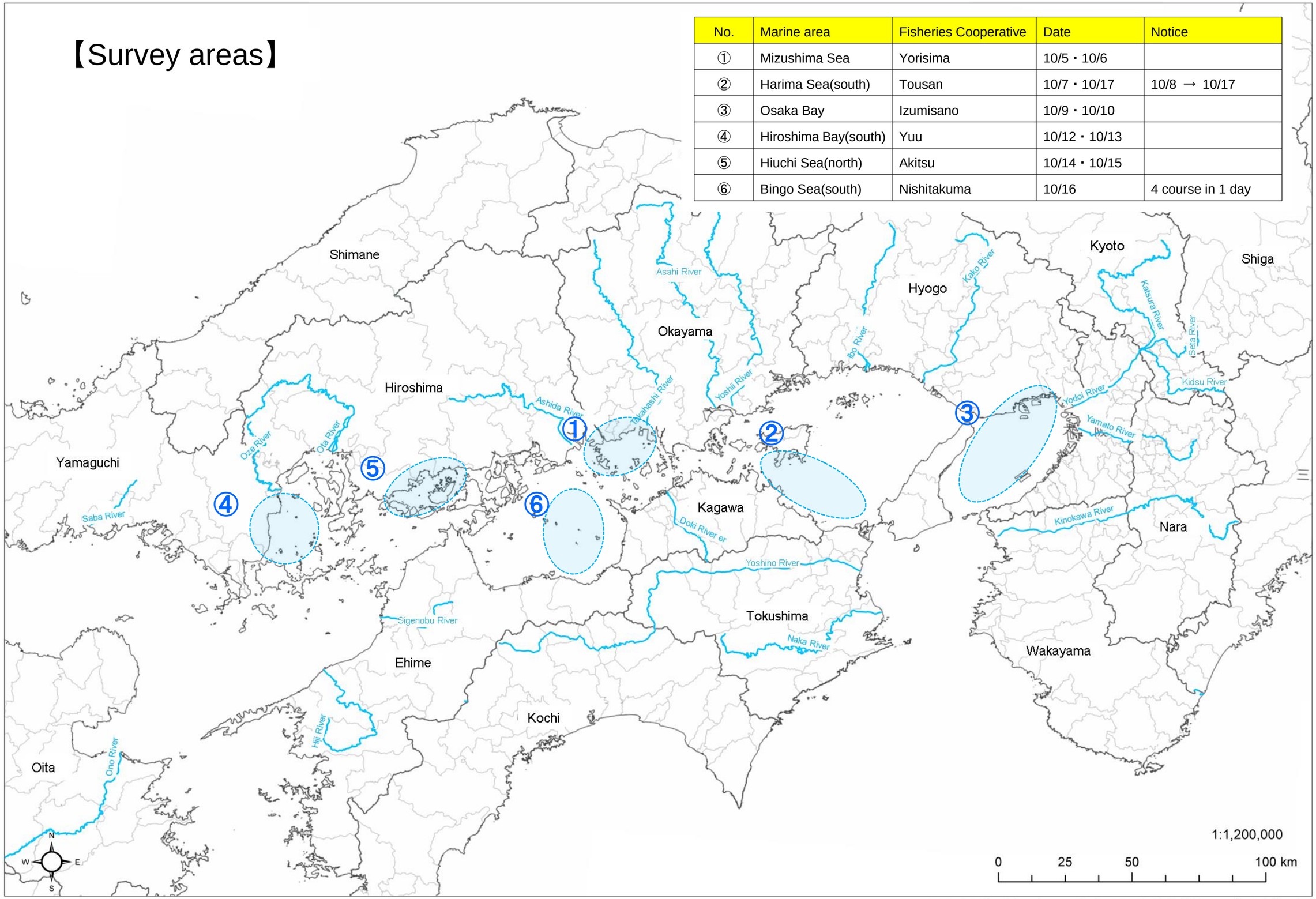
Chart II.2-1 Survey marine area

No	Bay/Sea	Date
①	Mizushima Sea	**10/5**・10/6
②	Harima Sea(south)	**10/7**・10/17
③	Osaka Bay	**10/9**・10/10
④	Hiroshima Bay(south)	**10/12**・10/13
⑤	Hiuchi Sea(north)	**10/14**・10/15
⑥	Bingo Sea(sorth)	**10/16**

* Large characters are dates of micro plastic survey

【Survey areas】

No.	Marine area	Fisheries Cooperative	Date	Notice
①	Mizushima Sea	Yorisima	10/5・10/6	
②	Harima Sea(south)	Tousan	10/7・10/17	10/8 → 10/17
③	Osaka Bay	Izumisano	10/9・10/10	
④	Hiroshima Bay(south)	Yuu	10/12・10/13	
⑤	Hiuchi Sea(north)	Akitsu	10/14・10/15	
⑥	Bingo Sea(south)	Nishitakuma	10/16	4 course in 1 day



国土地理院の電子地形図（白地図）と国土数値情報河川データを基に作成

Diagram II.2-2　Survey marine area

Diagram II.2-3　Survey line（Mizushima Sea）

Diagram II.2-4　Survey line（Harima Bay（south））

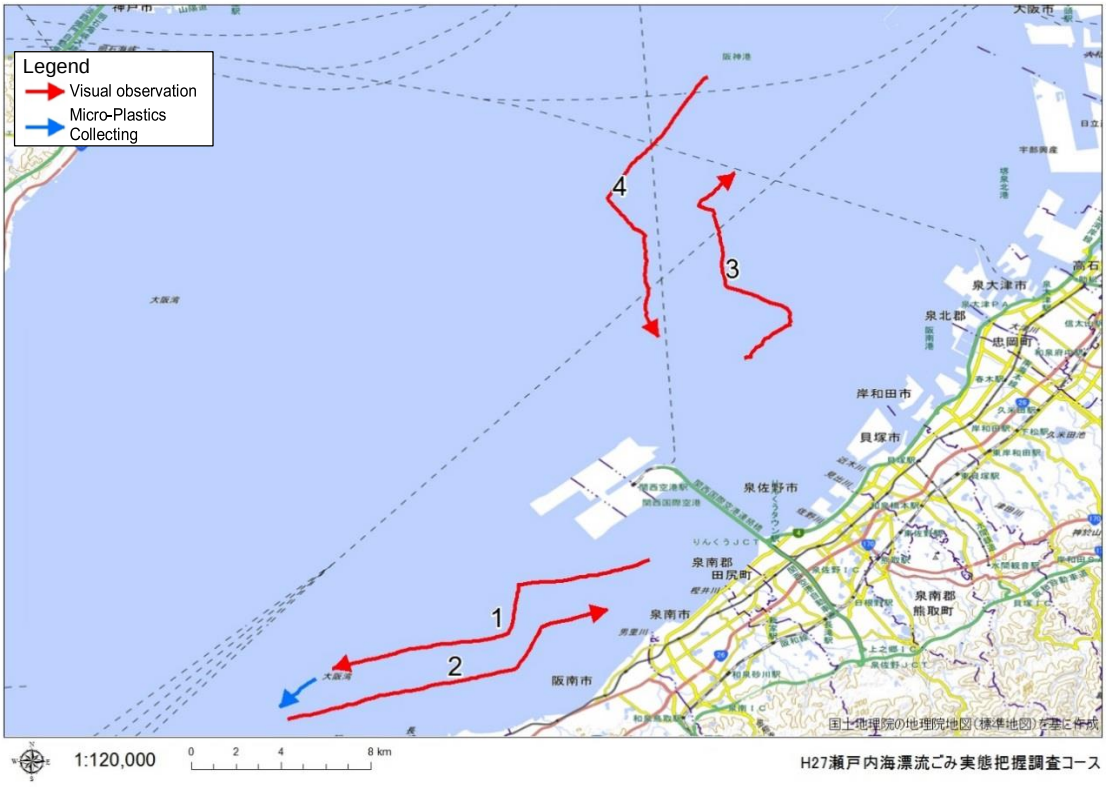


Diagram II.2-5　Survey line（Osaka Bay）

Diagram II.2-6　Survey line（Hiroshima Bay（south））

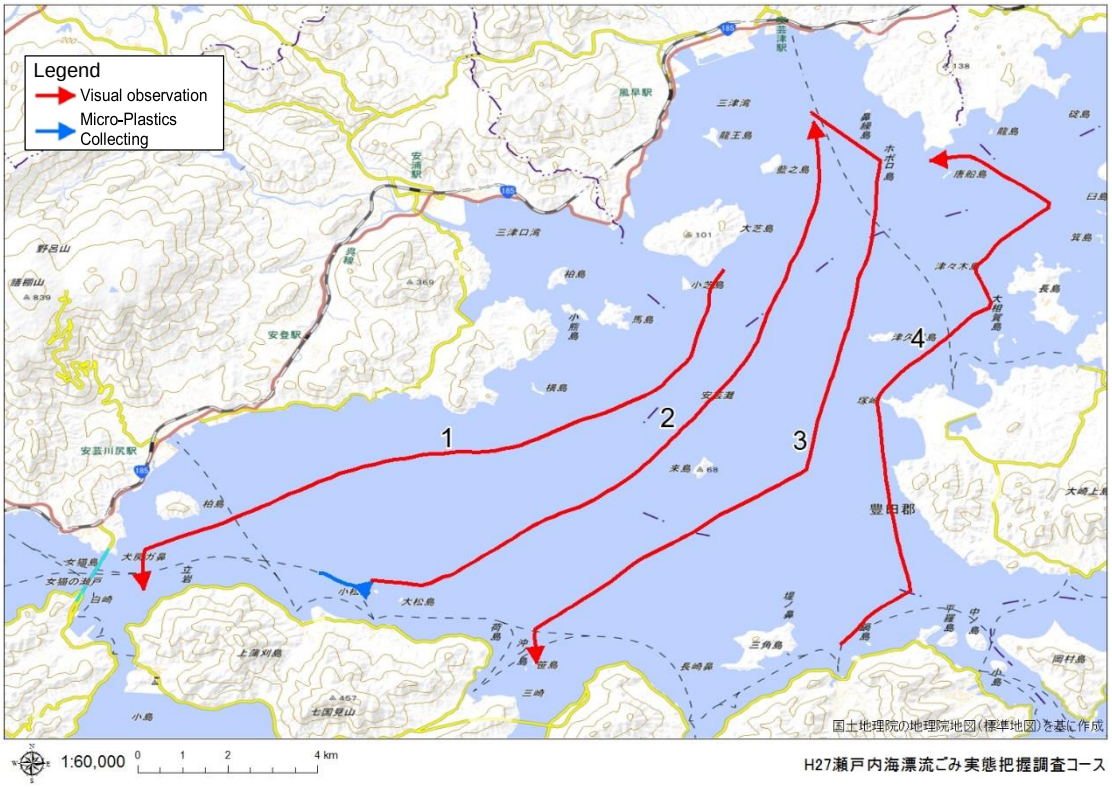


Diagram II.2-7　Survey line（Hiuchi Sea（north））

Diagram II.2-8　Survey line（Bingo Sea（south））

II.2.2 Survey Details

The details of the investigation, which was carried out are described below.

Chart II.2-9 Summary table of survey

Basic information					Weather conditions					Use ship			Total discovery (Number)
Order	Survey areas	Survey line	Date	Distance of Survey line (km)	Weather	Wind direction	Wind velocity (m/s)	oceanographic condition	Glare rate (%)	Length (m)	Gross weight (t)	Height of eye level (m)	
①	Mizushima Sea	1	2015/10/5	12.783	Cloudy	NNW	1.0	2	80	11.98	4.80	3.0	121
		2	2015/10/5	13.196	Cloudy	NNW	1.0	2	80	11.98	4.80	3.0	91
		3	2015/10/6	12.803	fine	NE	3.0	2	0	11.98	4.80	3.0	103
		4	2015/10/6	12.448	fine	NE	3.0	2	0	11.98	4.80	3.0	71
②	Harima Sea(south)	1	2015/10/7	11.589	fine	NW	5.0	2	0	8.25	2.16	2.0	257
		2	2015/10/7	11.889	fine	NW	3.0	1	0	8.25	2.16	2.0	133
		3	2015/10/17	13.209	fine	SSW	1.5	3	0	8.25	2.16	2.0	137
		4	2015/10/17	14.907	fine	SSW	1.5	3	0	8.25	2.16	2.0	205
③	Osaka Bay	1	2015/10/9	13.972	fine	NE	2.0	2	70	11.71	5.70	3.0	124
		2	2015/10/9	13.472	fine	NE	2.0	3	70	11.71	5.70	3.0	101
		3	2015/10/10	11.736	Cloudy	ENE	1.3	3	100	11.71	5.70	3.0	247
		4	2015/10/10	13.525	Cloudy	ENE	1.3	3	100	11.71	5.70	3.0	132
④	Hiroshima Bay(south)	1	2015/10/12	17.333	Cloudy	NW	2.0	3	60	9.78	3.30	3.0	123
		2	2015/10/12	13.853	Cloudy	NW	2.0	4	100	9.78	3.30	3.0	393
		3	2015/10/13	13.43	fine	N	1.0	2	0	10.86	4.00	3.0	88
		4	2015/10/13	18.26	fine	N	1.0	2	0	10.86	4.00	3.0	257
⑤	Hiuchi Sea(north)	1	2015/10/14	14.212	fine	N	3.6	1	0	10.40	4.46	2.0	255
		2	2015/10/14	14.524	fine	N	3.6	1	0	10.40	4.46	2.0	247
		3	2015/10/15	15.739	fine	NNE	3.0	2	50	13.21	4.70	3.0	199
		4	2015/10/15	14.629	fine	NNE	3.0	2	50	13.21	4.70	3.0	200
⑥	Bingo Sea(south)	1	2015/10/16	12.198	fine	E	3.0	2	10	9.10	2.40	2.0	466
		2	2015/10/16	14.003	fine	E	3.0	3	10	9.10	2.40	2.0	268
		3	2015/10/16	13.705	fine	E	3.0	2	10	9.10	2.40	2.0	330
		4	2015/10/16	16.821	fine	E	3.0	2	10	9.10	2.40	2.0	238

(1) Mizushima Sea

・Weather conditions

The first day was cloudy and the second day was clear.

The weather was mostly calm and the wave height and wind speed were not all that high.

・Use ship

Length approximately 12 m; weight 4.8 tons. This is the average size of the ships used in this survey.

・Characteristic floating debris

A relatively high number of natural objects such as seaweed were discovered. For artificial objects, the proportion of small Expanded Polystyrene pieces was high, but the absolute number was lower than other sea areas.

・Other

The degree of transparency was high.

No phenomena that affected the observations happened, and the survey could be conducted smoothly.

Picture II.2-10～17　The condition of survey

(2)Harima Sea (south)

・Weather condition

The weather was clear for the whole day on the first day and the second day. The wind speed was not all that high.

The waves were calm on the first day, but slightly high on the second day.

・Use ship

Length approximately 8 m; weight 2.2 tons

This is the smallest ship among those that were used in this survey.

・Characteristic floating debris

Many natural objects such as seaweed were discovered.

・Other

October 8 was scheduled to be the second day of the survey, but the waves were high and there was also a wind (wave height approximately 1 m and wind speed approximately 3 m), and the ship started swaying when it went offshore, so the team had to give up the visual survey and postpone it to October 17.

On the first day, 1 line was operated by 3 people and 2 lines were operated by 2 people. On the second day, 4 people operated the lines for the entire day.

Transparency on the sea was high.

According to the ship captain, there was a fast current in the survey sea area, and the current got faster as the ship got nearer to the east side of the survey area in particular (on the side of Naruto City, Tokushima Prefecture).






Picture II.2-18～25　The condition of survey

（3） Osaka Bay

・Weather condition

The first day was clear, and the second day was cloudy.

The weather was relatively calm on the first day, but it turned slightly cloudy on the second day, and there were some waves.

But the conditions on the second day did not affect operations.

・Use ship

Length approximately 11.7 m; weight 5.7 tons.

As a large ship was used, it did not sway even when there were some lateral waves, and the survey could be carried out under stable conditions.

・Characteristic floating debris

There were many artificial objects in their original form such as Expanded Polystyrene boxes and Plastic Bottles.

・Other

When collecting samples of Micro-Plastics, a large quantity of floating mud got caught in the net. A large number of krill also got into the net. The level of transparency was low and the color of the water was a deep dark green.






Picture II.2-26～33　The condition of survey

（4） Hiroshima Bay (south)

・Weather condition

The first day was cloudy and the second day was clear.

On the first day, it started raining towards the end of the first line and the survey was terminated for about 30 min.

After that, the waves got higher and the wind also became stronger in the middle of the second line.

On the second day, the skies were clear for the entire day and the sea was calm.

・Use ship

First day Length approximately 9.8 m; weight 3.3 tons

Second day Length approximately 10.9 m; weight 4.0 tons

As a large ship was used, it did not sway even when there were some lateral waves, and the survey could be carried out under stable conditions.

・Characteristic floating debris

There were many natural objects such as seaweed and driftwood (branches).

Judging from the color of Plastic Bags, food packaging, Plastic Bottles and other things, there was a lot of debris that appeared to have flowed into the sea for a short period of time only.

・Other

The waves were high but not to the extent that observation of floating debris could not be conducted. The sea conditions turned a bit rough for conducting observation towards the final stage of the second line on the first day. It is possible that floating debris in the valley between the waves could have been missed.






Picture II.2-34～41　The condition of survey

(5) Hiuchi Sea (north)

・Weather condition

The sky was clear for the entire day on both days.

The wind and waves were not strong, and the weather was calm and moderate.

・Use ship

First day　　Length approximately 10.4 m; weight 4.5 tons

Second day　Length approximately 13.2 m; weight 4.7 tons

The biggest ship was used on both days for the entire sea area.

・Characteristic floating debris

There was a very large amount of seaweed. Many small Expanded Polystyrene pieces were found, but other than that there were not many artificial objects.

・Other

This sea area has a high level of shielding as it is surrounded on four sides by islands and land.

There were many areas where it looked like the water surface was foamy or the water was stagnant.

Many rafts for aquafarming were installed near the fishing port.

Seaweed went into the net during sampling for Micro-Plastics, and a large quantity of Expanded Polystyrene which were caught in the seaweed were collected.






Picture II.2-42～49　The condition of survey

(6) Bingo Sea (south)

・Weather condition

Clear weather for the entire day.

There was a wind and also waves, but not to an extent that affected the observation.

・Use ship

Length approximately 9.4 m; weight 2.4 tons

The ship was comparatively smaller than those used in this survey, but it was a ship that was used to carry fishing visitors, so it was easy to conduct survey activities on the deck.

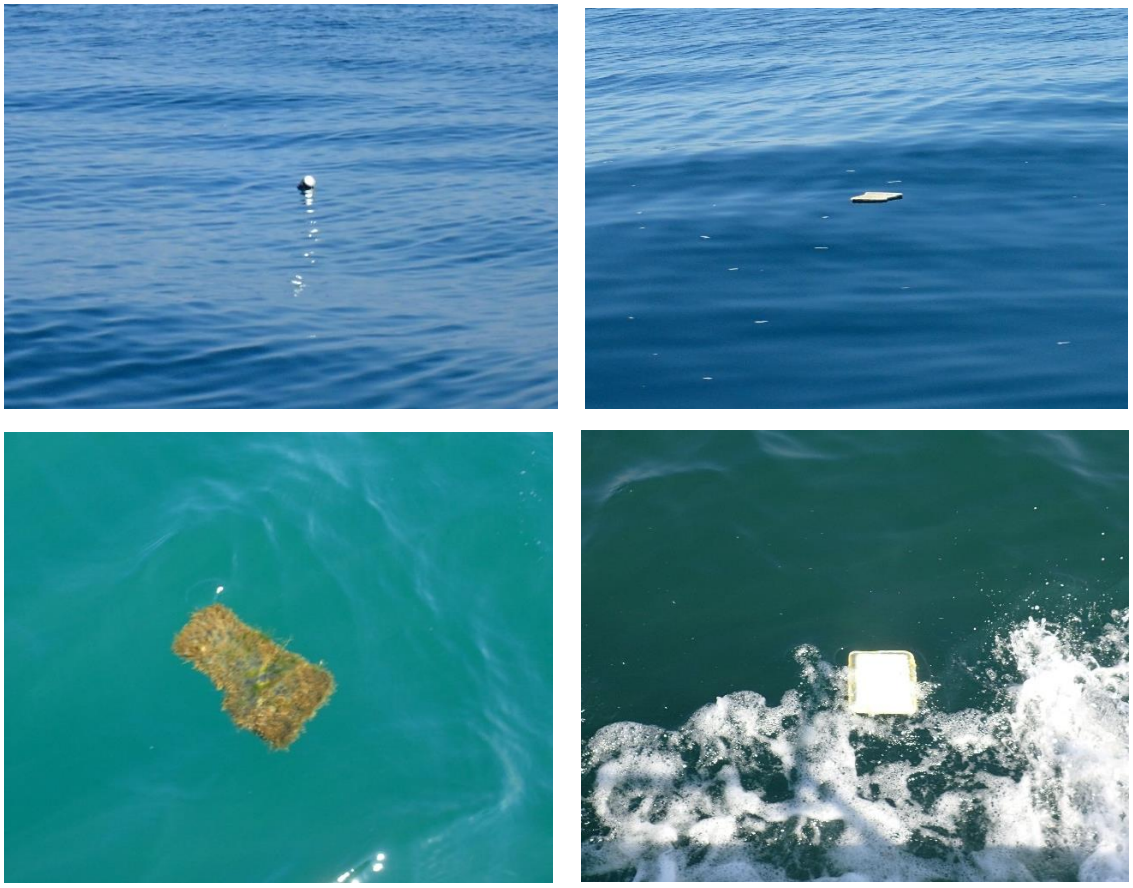
・Characteristic floating debris

Many objects such as Plastic Bottle caps were found which appeared to have been floating on the sea surface for a long time as seaweed was attached to the objects. There were also more rusted cans compared to other survey areas, and overall many old floating debris were found.

・Other

A large volume of debris was piled up near the mouth of Saitagawa River.

There was also more floating debris compared to other sea areas.



Picture II.2-50～57　The condition of survey

Chapter III　Current state analysis and Task management

In the first section of this chapter, “1. Analysis of locality”, we will consider the locality of marine debris floating on the surface of the Setonaikai by means of a comparison of the results of the 2014 Research in offshore areas (conducted from July through October 2014) with the results of this survey.

The next section “2. Analysis regarding the diversity of related entities” will examine the diversity of the entities related to the generation of floating debris by examining the origin of the floating debris found in this survey.

The section “3. Seasonal variation” will compare the results of the 2014 Research in coastal areas (conducted from the end of February through March 2014) with the results of this survey in order to examine the seasonal variation of the debris floating on the surface of the Setonaikai.

The last section, “4. Other issues”, will look into issues that require a revision of the methods of our survey work in the future.

Ⅲ.1.　Analysis of locality

When comparing the results of this survey with the results of the 2014 Research in offshore areas, the density of Petrochemicals and Expanded Polystyrene in the Setonaikai region in this survey (as of October 2015) is particularly high compared to offshore areas of Japan. The density of Plastic Bottles is slightly lower than in the East China Sea region but higher when compared to other marine regions (offshore areas). Further, Metal Goods and Glass goods similarly exhibit high densities (Chart III.1-1).

Meanwhile, the density of floating Micro-Plastics shows a low value in any offshore area of Japan, except for the Middle Pacific Ocean.

Chart III.1-1 Density of floating　debris in each marine sector (medians)

type of floating object	2014 Offshore areas							2014 Coastal areas	2015 Seto naikai
	East China Sea	Sea of Japan (west)	Sea of Japan (north)	Pacific Ocean (north)	Pacific Ocean (center)	Pacific Ocean (south)	Seto Inland Sea	Seto Inland Sea	Seto Inland Sea
Plastic Bottle	4.35	1.50	0.82	1.12	1.28	1.00	0.14	-	3.52
Expanded Polystyrene	9.43	3.66	3.05	1.63	1.30	0.75	0.93	1.94	25.17
Petrochemical*	33.89	21.86	19.88	13.96	14.68	14.76	15.0	16.74	165.05
Metal Goods	0.79	0.33	0.34	0.16	0.06	0.44	0.21	-	1.85
Glass goods	1.08	0.09	0.29	0.10	0.33	0.00	0.27	-	1.33
Micro-Plastic	0.59	1.23	0.73	1.22	0.00	15.75	-	0.04**	0.35

* Because of differences in the categorization of the floating　debris for this survey and the research conducted in past years, the total of the two types “Vinyl” and “Petrochemical” in the 2014 Research in offshore/coastal areas, and the total of the three types “Food Packaging”, “Plastic Bag” and “Petrochemical” in this survey are regarded as “Petrochemical”.

** In the 2014 Research in coastal areas, the density of Micro-Plastics of 1-5 mm

The results of this analysis indicate that there are more large-size floating　debris that are not turned into Micro-Plastics yet in the Setonaikai than in Japan’s offshore areas. It is assumed that the

reasons for this are, with regard to Food Packaging and Plastic bags, that the land from where the debris originates is close, and, with regard to Expanded Polystyrene, that there is an influence of the aquaculture and other fishing industry which is widely practiced in the Setonaikai.

However, there are still doubts as to whether conclusions regarding the locality may be drawn only on the basis of these densities. The vessels used in this survey and the 2014 Research in offshore areas were different. In the 2014 Research in offshore areas, height of perspective from which the observers watched the ocean was 14 m above sea level on the UMITAKA maru and 7 m above sea level on the SHINYO maru. In contrast, the height of perspective of the observers on the vessels used in this survey was approximately 2-3 m. The difference in the Effective Search Half-width depending on the height of perspective will be discussed under “4. Other issues” below, but it is highly probable that, as this survey was conducted from a perspective that was close to the water surface, small floating debris were observed that could not be found in the 2014 Research in offshore areas.

Chart III.1-2 Density by marine area in the 2014 Research in offshore areas

type of floating object	2014 Offshore areas（SHINYO maru）		2014 Offshore areas（UMITAKA maru）						Median
	Harima Sea	Suoh Sea	Itsuki Sea	Hiroshima Bay	Iyo Sea (north)	Suoh Sea (west)	Suoh Sea	Suoh Sea (east)	
Plastic Bottle	-	0.80	0.60	-	-	-	-	-	0.70
Expanded Polystyrene	1.40	1.40	0.54	-	0.25	-	-	1.36	1.36
Petrochemical	42.1	50.0	3.57	0.18	10.6	5.18	7.76	10.0	8.88
Metal Goods	-	1.77	-	-	-	-	-	-	1.77
Glass goods	0.27	1.98	-	-	0.15	-	-	0.35	0.31

“-“ means that no applicable object was found

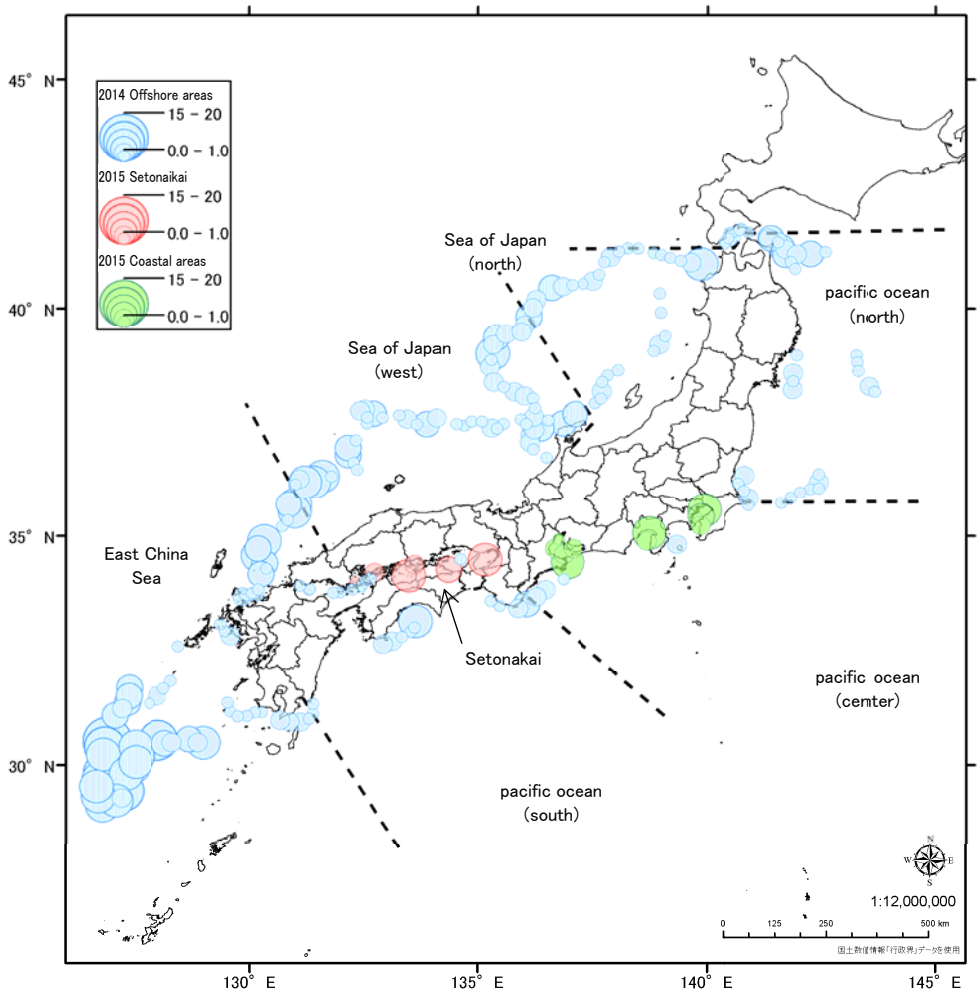
Chart III.1-3 Density by area in this survey

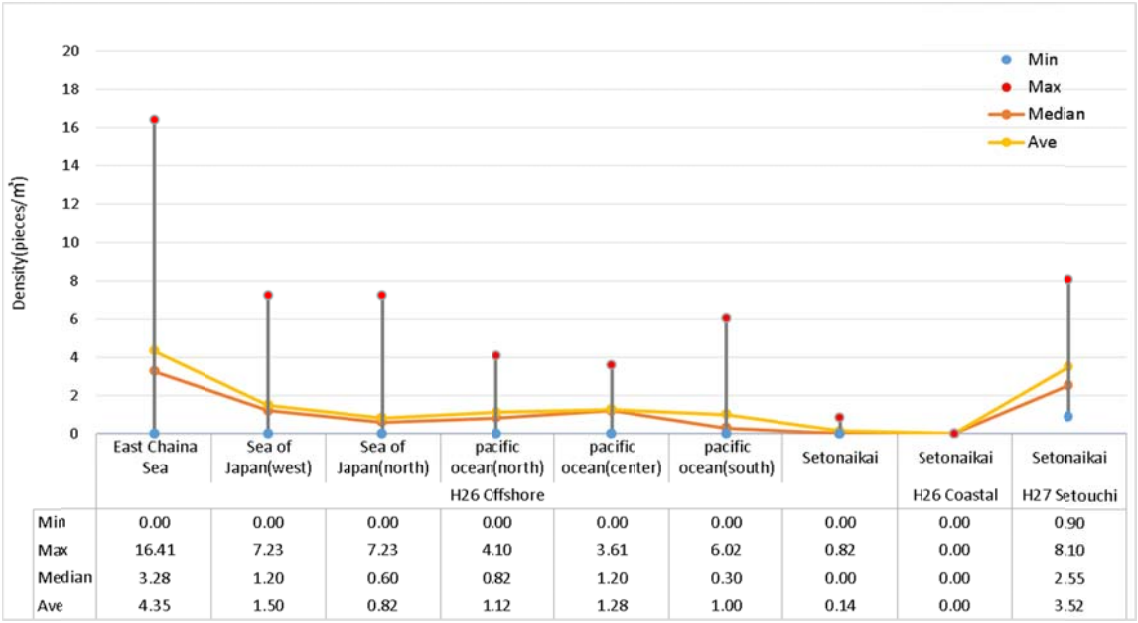
type of floating object	2015 Setonaikai						Median
	Osaka Bay	Harima Sea (south)	Mizushima Sea(sorth)	Bingo Sea (sorth)	Hiuchi Sea(north)	Hiroshima Bay(south)	
Plastic Bottle	8.10	3.20	1.30	5.70	1.90	0.90	2.55
Expanded Polystyrene	26.6	18.3	19.7	28.5	40.8	17.1	23.15
Petrochemical	267.4	123.2	59.2	366	100.3	73.9	111.75
Metal Goods	3.00	2.80	0.30	3.30	1.20	0.50	2.00
Glass goods	0.90	0.90	1.90	4.30	-	-	1.40

When looking at the observation results of the 2014 Research in offshore areas (Chart III.1-2), no significant differences from this survey can be found in the density of debris such as Plastic Bottle, Metal Goods (mainly beverage cans), or Glass Goods (mainly bottles) the form and size of which is fixed to a certain extent, while major differences can be found in the density of debris having a varying form and size, for example, Expanded Polystyrene and Petrochemical. Since the surveyed marine areas are not the same, it is not possible to make a true comparison, but the research

conducted by UMITAKA maru and SHINYO maru shows the same tendency.

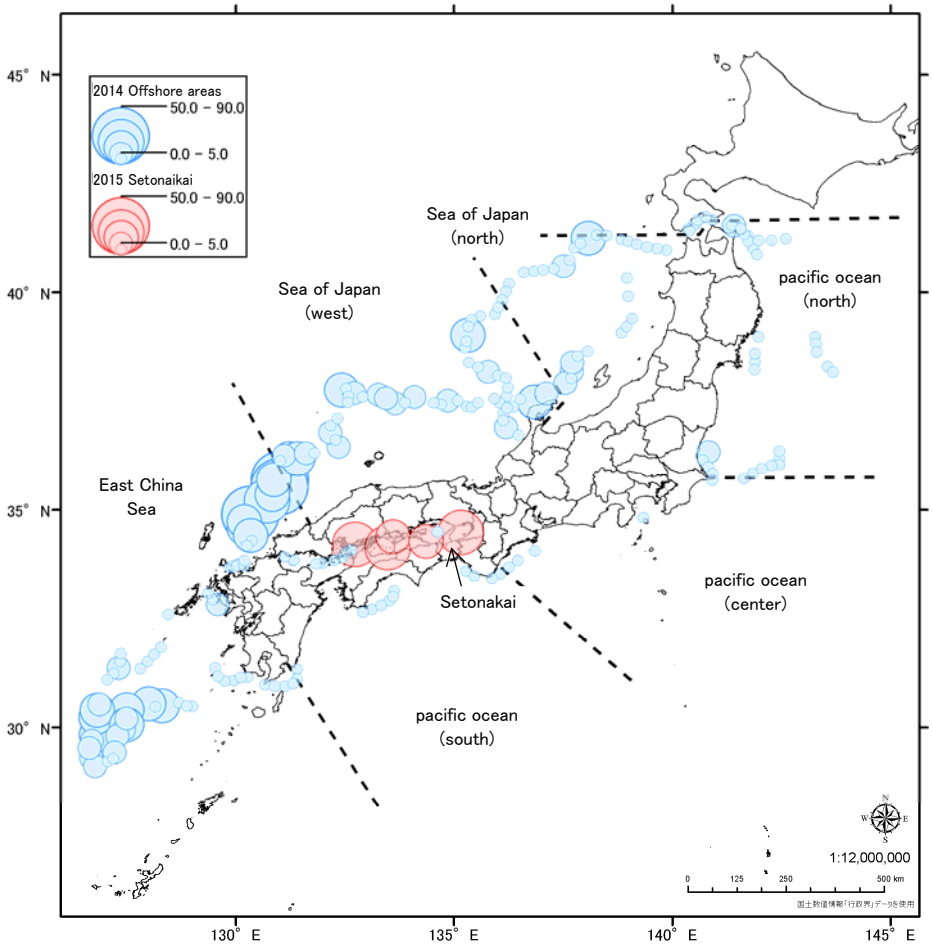
For a more adequate comparison, it will probably be possible to consider the variation in the discovered quantities due to the height of perspective during the analysis if we establish a new category for sizes that can only be discovered when the observer is close to the water surface. Concretely speaking, if we establish, within the category SS of the present research for floating debris of less than 20 cm, a category for a size (for example, less than 10 cm) that can be observed from a fishing vessel but not if the height of perspective is at or above a certain level (for example, 5 m), and then compare the results after having excluded the count of this new category, it should be possible to determine a more accurate locality from which differences in the conditions due to different ships are eliminated.

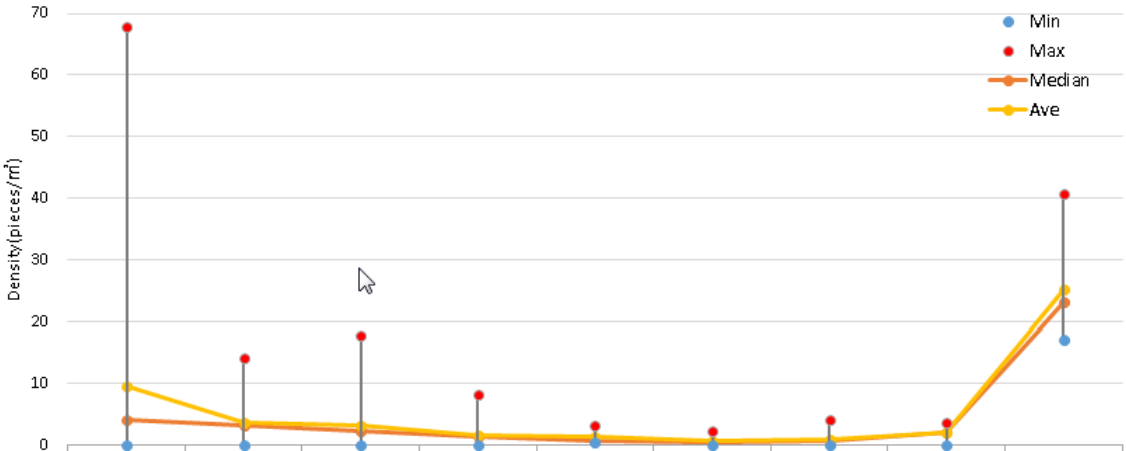




	East Chaina Sea	Sea of Japan(west)	Sea of Japan(north)	pacific ocean(north)	pacific ocean(center)	pacific ocean(south)	Setonaikai	Setonaikai	Setonaikai
	H26 Offshore							H26 Coastal	H27 Setouchi
Min	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.90
Max	16.41	7.23	7.23	4.10	3.61	6.02	0.82	0.00	8.10
Median	3.28	1.20	0.60	0.82	1.20	0.30	0.00	0.00	2.55
Ave	4.35	1.50	0.82	1.12	1.28	1.00	0.14	0.00	3.52

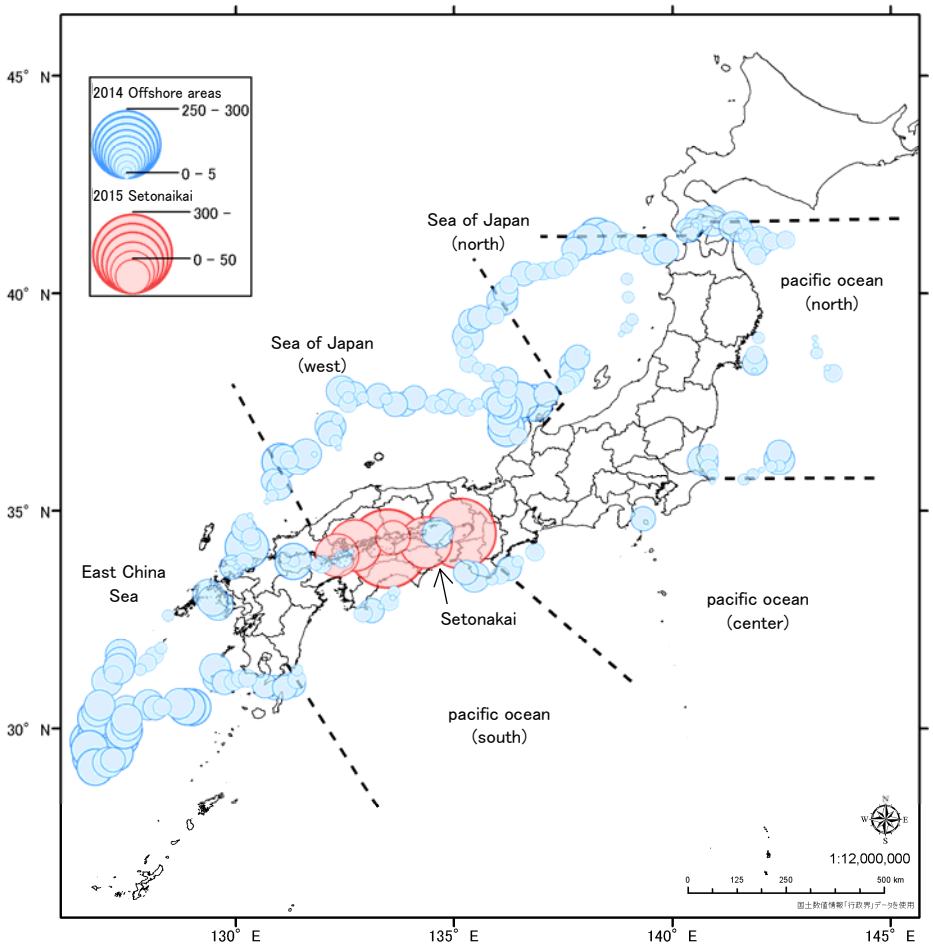
Diagram Ⅲ.1-1 and 2 Density of marine area (Plastic Bottle)

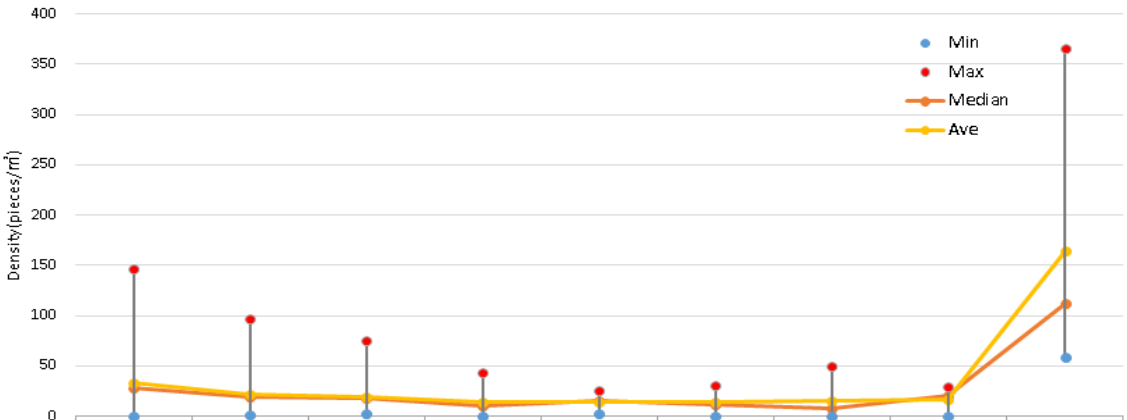




	East Chaina Sea	Sea of Japan(west)	Sea of Japan(north)	pacific ocean(north)	pacific ocean(center)	pacific ocean(south)	Setonaikai	Setonaikai	Setonaikai
	H26 Offshore							H26 Coastal	H27 Setouchi
Min	0.00	0.00	0.00	0.00	0.45	0.00	0.00	0.00	17.10
Max	67.79	14.10	17.64	8.19	3.26	2.27	4.09	3.60	40.80
Median	4.09	3.26	2.17	1.36	0.73	0.41	0.54	2.00	23.15
Ave	9.43	3.66	3.05	1.63	1.30	0.75	0.93	1.94	25.17

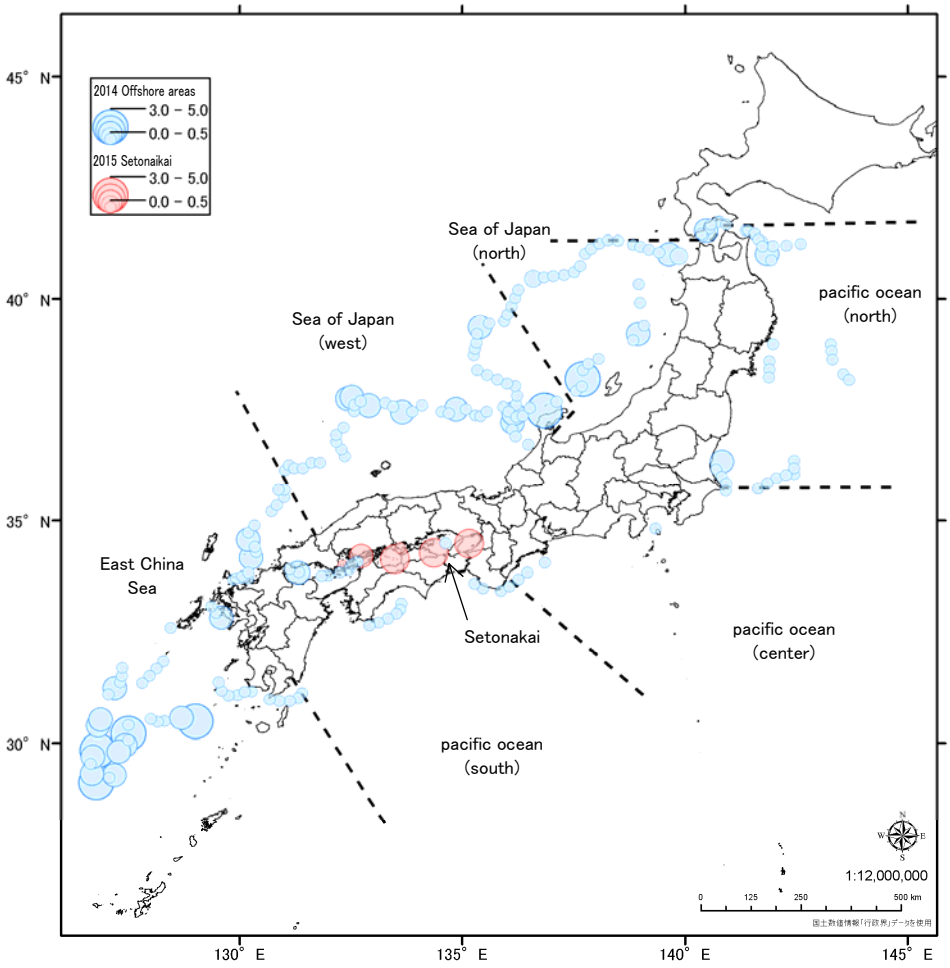
Diagram Ⅲ.1-3 and 4 Density of marine area (Expanded Polystyrene)

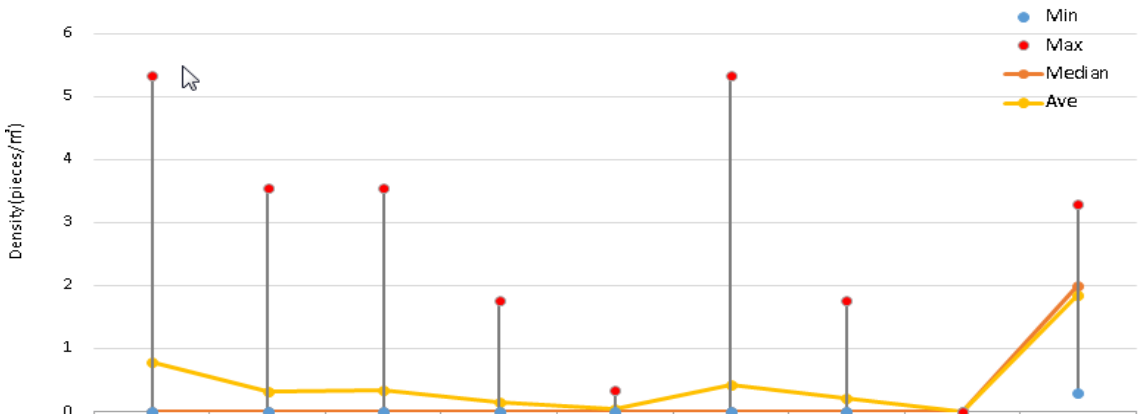




	East Chaina Sea	Sea of Japan(west)	Sea of Japan(north)	pacific ocean(north)	pacific ocean(center)	pacific ocean(south)	Setonaikai	Setonaikai	Setonaikai
	H26 Offshore							H26 Coastal	H27 Setouchi
Min	0.00	1.14	2.27	0.37	3.41	0.18	0.18	0.60	59.20
Max	146.34	96.79	75.04	43.74	26.00	30.19	50.02	29.00	366.00
Median	28.22	18.85	17.50	10.37	15.16	12.01	7.30	21.00	111.90
Ave	33.89	21.86	19.88	13.96	14.68	14.76	15.00	16.74	165.05

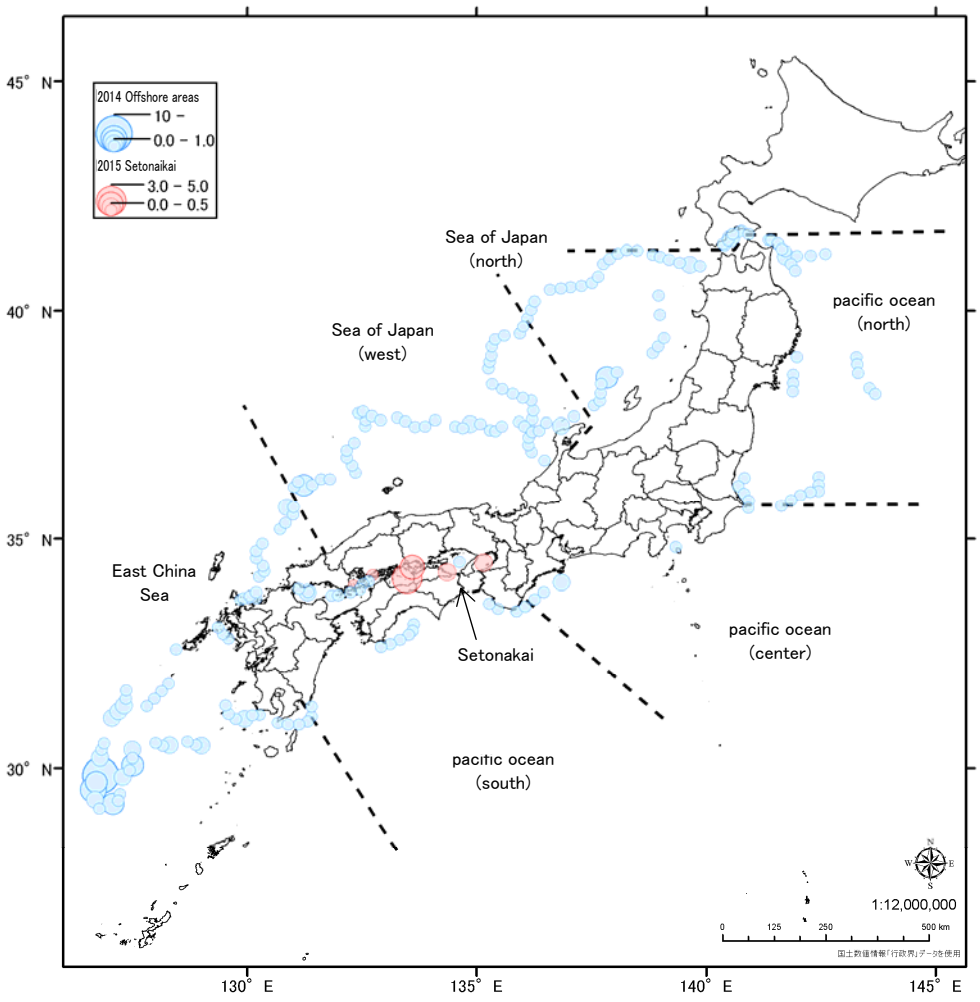
Diagram Ⅲ.1-5 and 6 Density of marine area (Petrochemical)

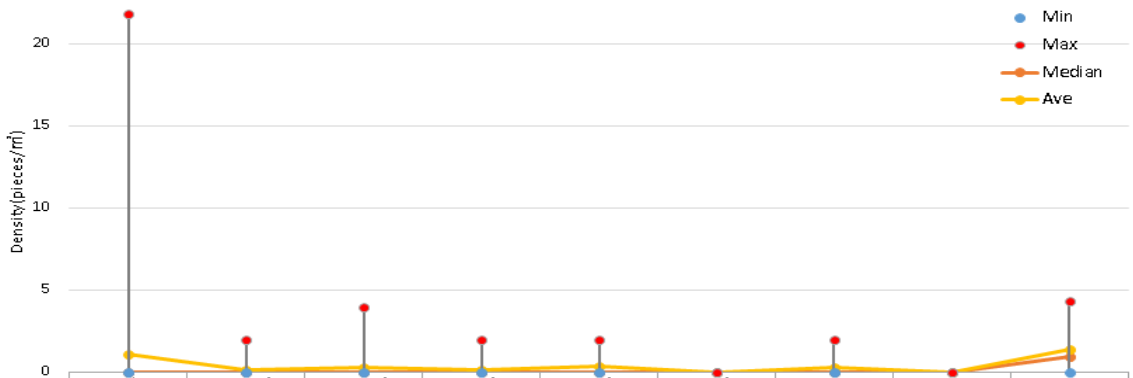




	East Chaina Sea	Sea of Japan(west)	Sea of Japan(north)	pacific ocean(north)	pacific ocean(center)	pacific ocean(south)	Setonaikai	Setonaikai	Setonaikai
	H26 Offshore							H26 Coastal	H27 Setouchi
Min	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.30
Max	5.33	3.56	3.56	1.78	0.34	5.33	1.78	0.00	3.30
Median	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00
Ave	0.79	0.33	0.34	0.16	0.06	0.44	0.21	0.00	1.85

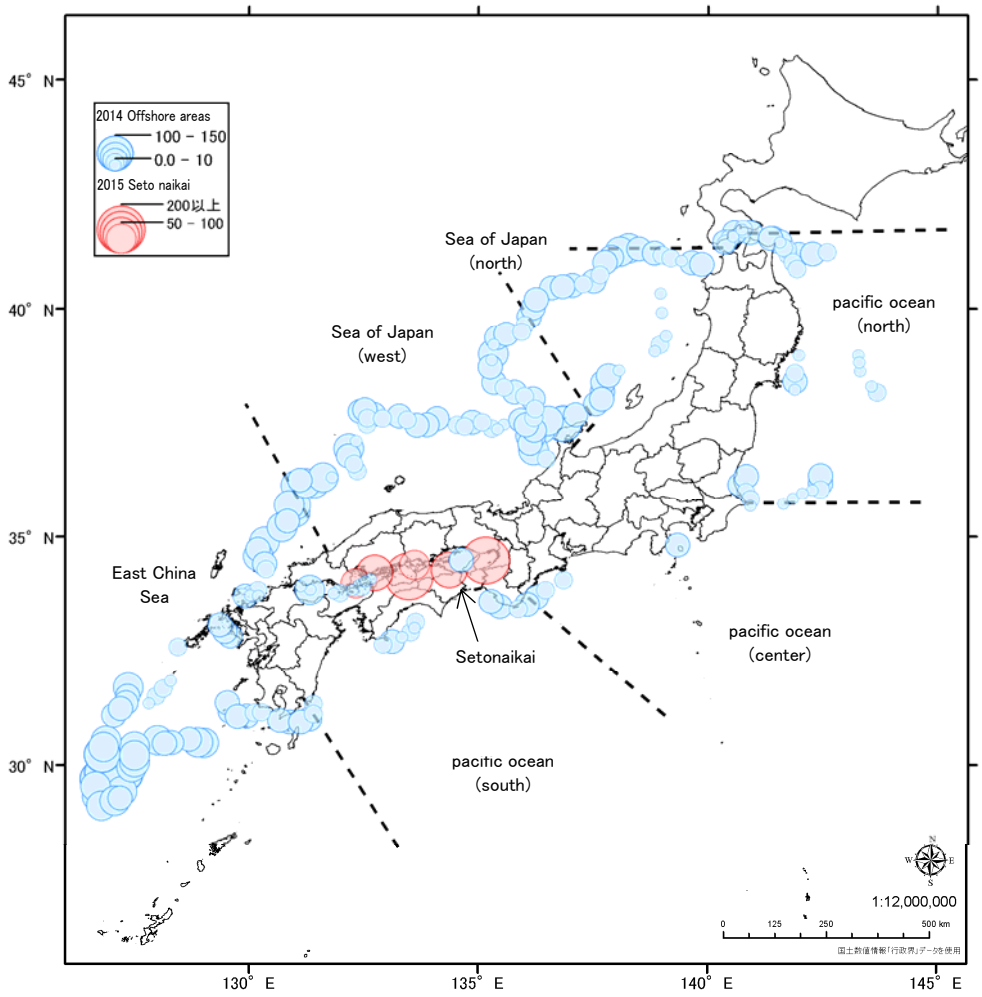
Diagram Ⅲ.1-7 and 8　Density of marine area (Metal Goods)

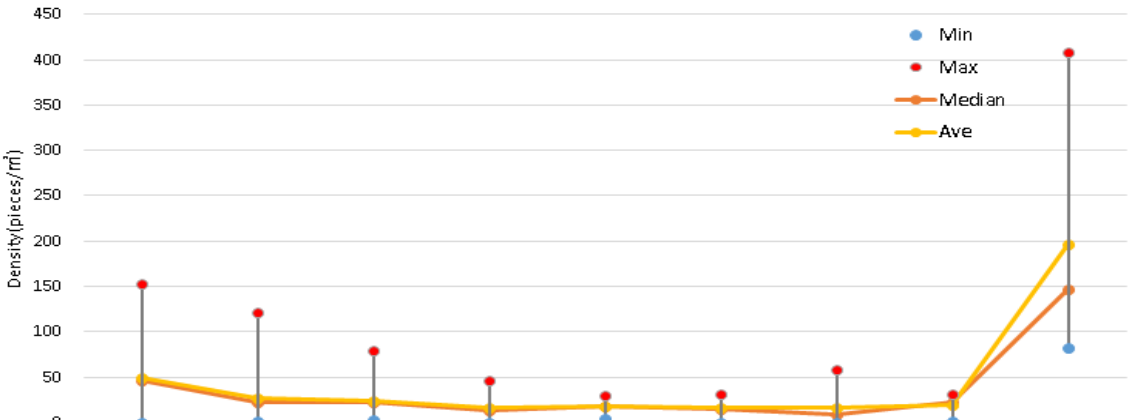




	East Chaina Sea	Sea of Japan(west)	Sea of Japan(north)	pacific ocean(north)	pacific ocean(center)	pacific ocean(south)	Setonaikai	Setonaikai	Setonaikai
	H26 Offshore							H26 Coastal	H27 Setouchi
Min	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Max	21.83	1.98	3.97	1.98	1.98	0.00	1.98	0.00	4.30
Median	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.90
Ave	1.08	0.09	0.29	0.10	0.33	0.00	0.27	0.00	1.33

Diagram Ⅲ.1-9 and 10 Density of marine area (Glass goods)





	East Chaina Sea	Sea of Japan(west)	Sea of Japan(north)	pacific ocean(north)	pacific ocean(center)	pacific ocean(south)	Setonaikai	Setonaikai	Setonaikai
	H26 Offshore							H26 Coastal	H27 Setouchi
Min	0.00	1.14	3.18	0.37	3.86	0.46	0.18	0.60	82.40
Max	153.22	121.36	79.99	46.58	29.71	31.06	58.69	32.00	407.80
Median	45.66	22.98	21.85	13.77	18.45	14.95	8.35	22.00	146.45
Ave	49.54	27.44	24.38	16.97	17.64	16.97	16.55	18.69	196.92

Diagram Ⅲ.1-11 and 12　Density of marine area (Unnatural five kinds)

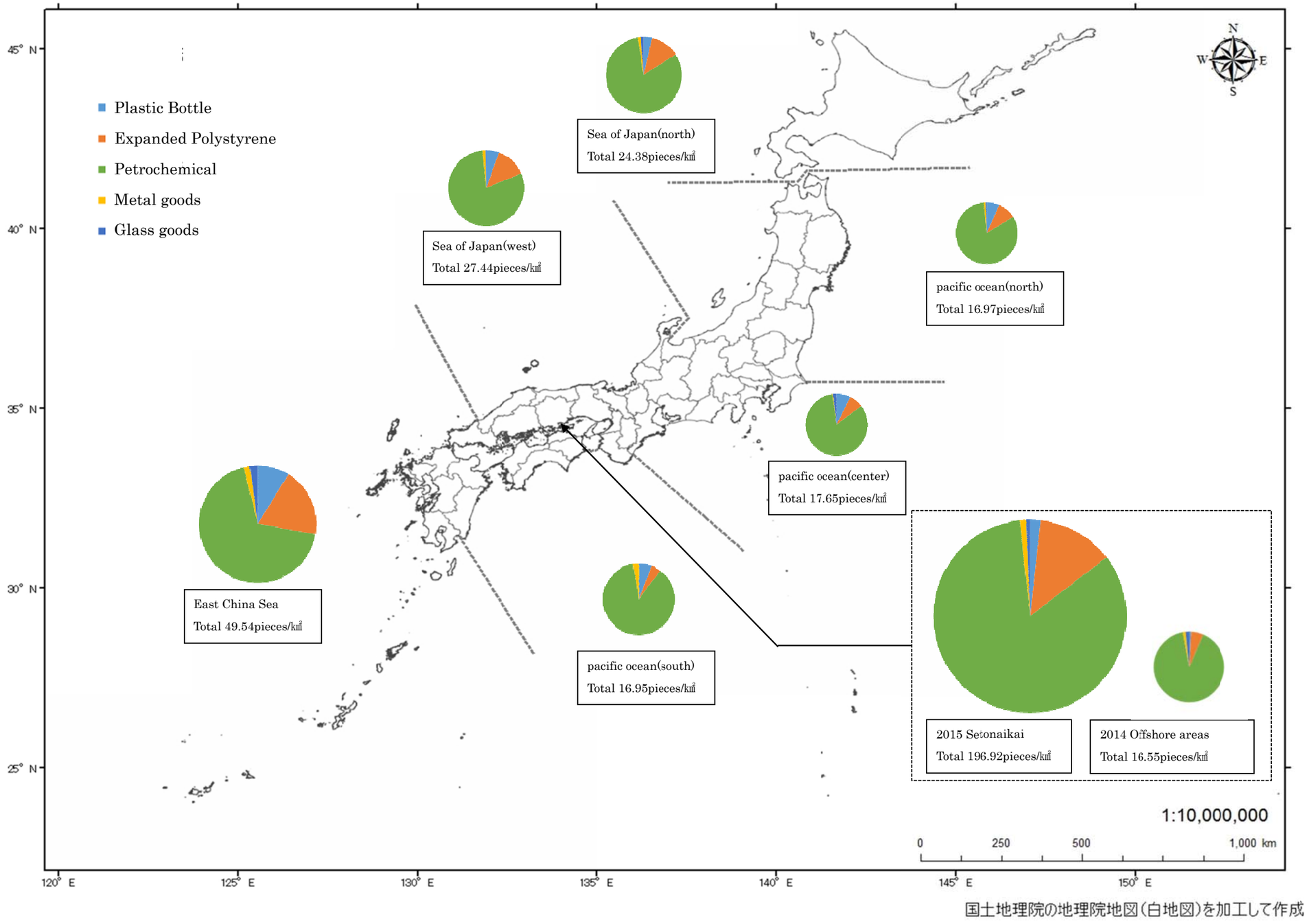
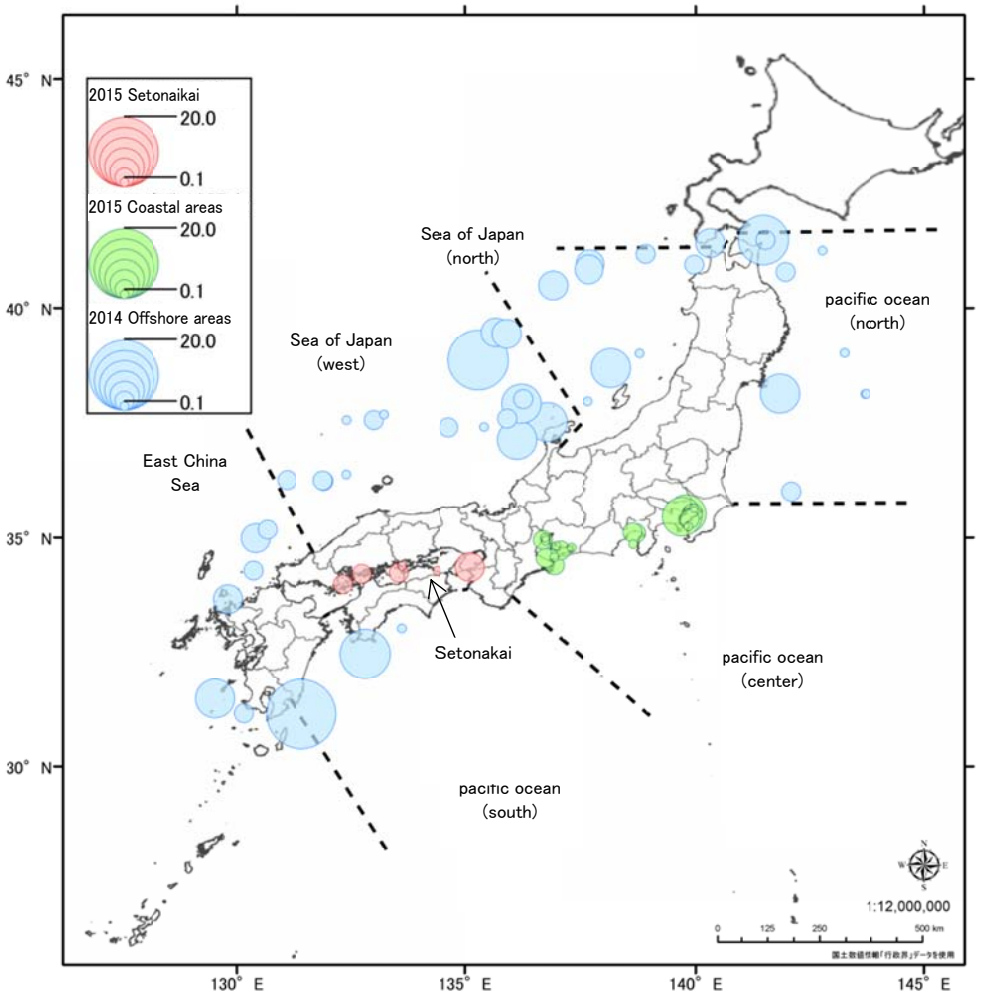
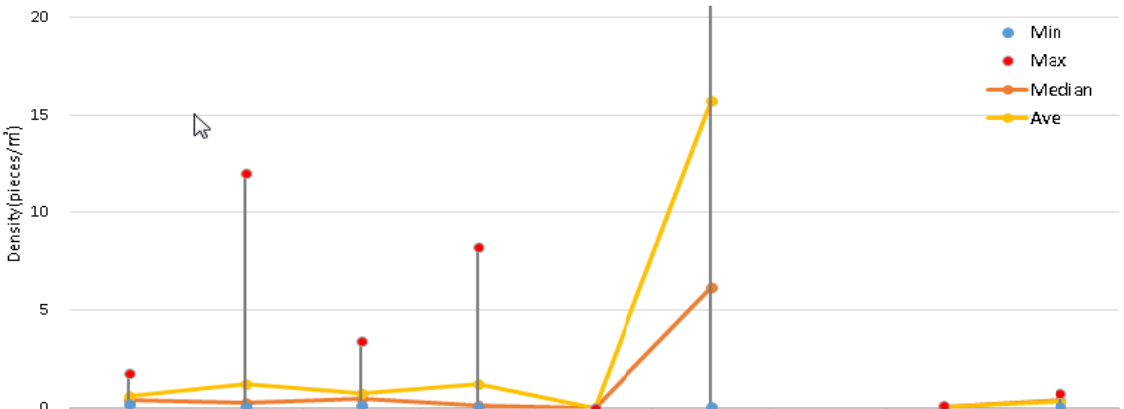


Diagram Ⅲ.1-13　Unnatural five kinds of marine area average, total (Plastic Bottle, Expanded Polystyrene, Petrochemical, Metal goods, Glass goods)





	East Chaina Sea	Sea of Japan(west)	Sea of Japan(north)	pacific ocean(north)	pacific ocean(center)	pacific ocean(south)	Setonaikai	Setonaikai	Setonaikai
	H26 Offshore							H26 Coastal	H27 Setouchi
Min	0.16	0.06	0.09	0.03	0.00	0.05		0.00	0.03
Max	1.77	12.00	3.43	8.21	0.00	41.02		0.10	0.75
Median	0.40	0.22	0.44	0.11	0.00	6.19		0.04	0.42
Ave	0.59	1.23	0.73	1.22	0.00	15.75		0.04	0.35

Diagram Ⅲ.1-14 and 15 Density of marine area (Micro-Plastics)

Ⅲ.2. Analysis regarding the diversity of related entities

Much of the floating debris in the Setonaikai consists of plastic products such as Food Packaging and Plastic bags (Chart III.1-1). This type of debris is household waste originating from land areas and probably floating on the ocean surface after having flown in from a river or the like.

As was examined in Chapter II 3-4, this kind of debris existing in a marine area does not only include debris that flowed into the sea from the nearest river, but also debris that flowed in from a river of another marine area and drifted to the marine area where it was found. In the Mizushima Sea (south) and the Hiroshima Bay, there were less artificial floating debris than in other marine areas despite a continuing inflow from large rivers. In Bingo Sea, on the contrary, the inflow from rivers is not very large (the length of the nearest river is short and the basin area small), but the quantity of floating debris was extremely large.

Rivers are managed by the regional development bureaus of the Ministry of Land, Infrastructure and Transport, the prefectural governments and municipal governments on their respectively designated sections, while the responsibility for the management of the coasts is divided as shown in Chart III.2-1 “Basic Areas of Response by Coast Management Entity”. Further, assuming that the floating debris do not originate only from the nearest river, it is not possible to consider only the prefectures or municipalities managing the river that is closest to the place where the debris was found, as the related entities. Particularly the Setonaikai has eleven prefectures directly facing the coastline, and all of these are considered to be related entities.

Further, since this survey only found a small quantity of fishing gear but large quantities of Expanded Polystyrene, the fishermen’s unions of the eleven prefectures must also be included into the related entities, which means that the related entities are extremely diverse (Diagram II.3-1-15 Density by type of floating object).

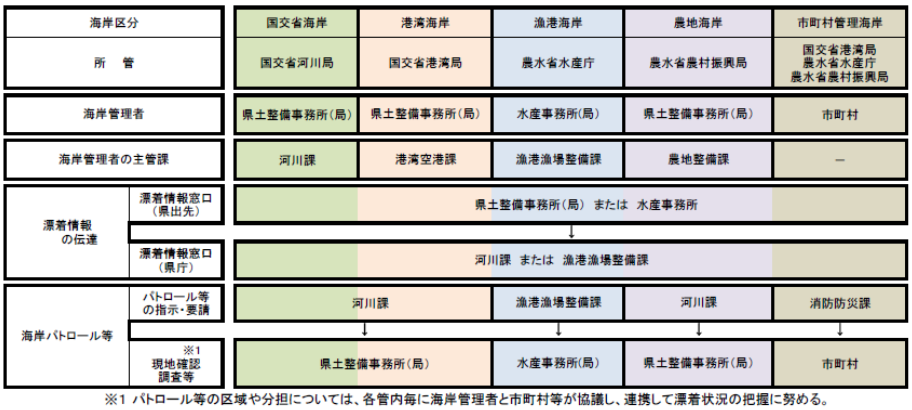


Chart III.2-1 Basic Areas of Response by Coast Management Entity (from the Manual for Initial Response to Floating Debris, Shimane Prefecture).

Ⅲ.3. Seasonal variation

<Comparison of floating debris>

To take a look at the influence of seasonal variation, we compared this survey (conducted in October 2015) with the 2014 Research in coastal areas (conducted from February through March). However, since the 2014 Research in offshore areas estimated the density of only three types for which the Effective Search Half-width was determined, namely Plastic sheet (the total of Plastic bags and Food Packaging in this survey), Expanded Polystyrene and Petrochemical (the name in the 2014 Research in offshore areas is Petrochemical), we used the data of these three types for the comparison with this survey (Chart III.3-3-1).

The comparison revealed that the density floating debris in the Setonaikai during this survey was extraordinarily high in all marine areas. This fits in with the anticipation that the quantity of floating debris increases in autumn, because there is more precipitation than in winter and thus more inflow from the rivers.

When looking at the results by type of floating debris, the density of Plastic sheets is the highest in both surveys in Bingo Sea (south), while Hiroshima Bay (south) and Mizushima Sea (south) both show a tendency towards a low density. However, the medians of the densities differ by as much as 500%. Similarly, there is a difference of approximately 1300% in the density of Expanded Polystyrene and approximately 3600% for Petrochemical.

Chart III.3-3-1 Comparison of density by marine area (number/km^2)

調査地域	2014 Coastal areas				2015 Setonaikai			
	Plastic sheet	Expanded Polystyrene	Petrochemical	Total	Plastic bags ＋ Food Packaging	Expanded Polystyrene	Petrochemical	Total
Osaka Bay	17.0	3.6	5.5	26.1	106.3	26.6	161.1	294.0
Harima Bay(south)	20.0	1.0	1.0	22.0	50.9	18.3	72.3	141.5
Mizushima Sea(sorth)	5.0	2.0	0.5	7.5	34.3	19.7	24.9	78.9
Bingo Sea(sorth)	27.0	3.0	2.0	32.0	152.3	28.5	213.7	394.5
Hiuchi Sea(north)	15.0	2.0	6.6	23.6	53.3	40.8	47.3	141.4
Hiroshima Bay(south)	0.6	0.0	0.0	0.6	24.7	17.1	49.2	91.0
Density (Average)	14.1	1.9	2.6	18.6	70.3	25.2	94.8	190.2

<Comparison of Micro-Plastics>

Because the analysis of Micro-Plastics in the 2014 Research in coastal areas was conducted on pieces of a size of 1-5 mm out of the collected samples, we conducted the comparison using pieces of the same size, 1-5 mm, extracted from the results of this survey.

The results are as shown in Chart II.3-2-3. Further, the density of Plastics and Expanded Polystyrene by marine area is shown in Diagrams II.3-2-3, 4, 5 and 6.

Chart III.3-3-2 Results of the comparison of Micro-Plastics with the 2014 Research in coastal areas

Marine area	2015 Setonaikai (1～5mm)						2014 Coastal areas					
	Plastic	Density (peace/m³)	Expanded Polystyrene	Density (peace/m³)	Lint	Density (peace/m³)	Plastic	Density (peace/m³)	Expanded Polystyrene	Density (peace/m³)	Lint	Density (peace/m³)
Mizushima Sea	7	0.025	35	0.126	0	0.000	1	0.003	0	0.000	0	0.000
Harima Sea(south)	4	0.019	11	0.052	0	0.000	16	0.038	3	0.007	0	0.000
Osaka Bay	100	0.446	6	0.027	1	0.004	7	0.034	0	0.000	0	0.000
Hiroshima Bay(south)	39	0.181	47	0.218	0	0.000	2	0.005	1	0.003	0	0.000
Hiuchi Sea(north)	68	0.271	599	2.387	6	0.024	1	0.004	26	0.094	0	0.000
Bingo Sea(south)	121	0.417	6	0.021	2	0.007	7	0.021	5	0.015	0	0.000

The comparison of this survey with the 2014 Research in coastal areas revealed that the density significantly increases in all marine areas except for Harima Sea (south), and that more Micro-Plastics can be found in the summer season than in the winter season. As for Harima Sea (south), the density of Micro-Plastics was 0.038 number/m^3 in the 2014 Research in coastal areas and 0.019 number/m^3 in this survey, and only in this marine area, the density of Micro-Plastics is lower during the summer season (Chart III.3-3-2). When comparing the precipitation, river inflow and wind direction during the months of February and October at Harima Sea (south), it is the wind direction that shows the largest differences (refer to Diagram II.3-3-6). The origin of the collected Micro-Plastics is not easy to identify, but it is possible that the Micro-Plastics floating in the surface layer of the ocean are carried from the Honshu-side to the Shikoku-side by a wind current caused by a wind from west-northwest. However, at this point of time, we do not have sufficient data to prove this. Also to verify whether this phenomenon is temporary, we consider it important to continue accumulating data.

Tendencies that could be found in the results of the two surveys include that, when comparing areas within the Setonaikai, Osaka Bay and Bingo Sea (south) exhibit a higher density than other areas, and that the density of Expanded Polystyrene is extraordinarily high in the Hiuchi Sea (north).

However, while the 2014 Research in coastal areas used sieves of 5 mm and 1 mm for a microscopic examination by means of a stereoscopic microscope, we used sieves of 2.0 mm and 300

μm and then identified the material by FT-IR at the Research Institute for Applied Mechanics, Kyushu University, in this survey. It is undeniable that the number of discovered pieces could have been slightly larger if the 2014 Research in coastal areas had used the same method.

Ⅲ.4. Other issues

Concerning the research methods, differences in the height of perspective of the observer on the vessel affect the quantity and density of discovered objects, and in this respect, the conditions in this survey and the 2014 Research in offshore areas were different. The height of perspective during the 2014 Research in offshore areas was 14 m on the UMITAKA maru and 7 m on the SHINYO maru. Meanwhile, the height of perspective of the observers on the vessels used in this survey was approximately 2-3 m at the most. In addition, the discovery rate may have been influenced by the fact that, unlike the research in offshore areas and coastal areas of 2014, the visual survey in this survey was conducted by two persons each positioned on the starboard side and two persons positioned on the port side in order to prevent that objects were overlooked or mistaken.

When looking at the tendencies of the discovered objects, most of the discovered objects in the 2014 Research in offshore areas were artificial, with natural items such as drifting seaweed or driftwood occupying not more than one third of the total. Meanwhile, in this survey, the number of discovered natural objects occupies 60% of the total, which reverses the results of the offshore research. The depth of the water, the distance from the coast and the like during the survey are considered to be factors for this, but it is possible that, since the observers were close to the water surface in this survey, they counted smaller floating debris that could not be observed during the offshore research. As was also mentioned in “1. Analysis of locality” in this chapter III, we think that it is necessary to establish a new size category for sizes that can only be discovered when the observers are close to the water surface.

On the other hand, it is well possible that distant objects were overlooked in this survey. This is backed up by the differences in the Effective Search Half-width during the respective surveys shown in Charts III.4-1 to 4-3. When comparing the results of the 2014 Research in offshore areas and 2014 Research in coastal areas with the results of this survey, it is obvious that the Effective Search Half-width in the offshore research is larger and that it was possible to discover objects in a greater distance.

We believe that it is necessary to correct the excess of the density among the marine areas while considering also the sizes of the survey vessels and the systems under which the survey was actually performed.

During interviews with the captains of the fishing vessels used in this survey and with persons involved in fishermen’s unions, we were frequently told that there is more debris during the rainy

season of June and July than in October, when this survey was conducted. When taking a closer look at the precipitation, the rainfall has its peak from the rainy season (June and July) through the typhoon season (July to September), then becomes less during October, increases again during November and December and reaches its minimum in February. The peak of river inflow is in September and the minimum is reached in May.

For these reasons, we believe that the seasonal variation will become clearer if a survey is conducted during May or the rainy season of June/July in addition to the past surveys (end of February and beginning of October).

Speaking about the timing of the research, committee members at the review meeting told us that they are of the opinion that the time it takes for the water from a river to pass through the surveyed marine area, should also be taken into consideration. In any case, it is important to continue the research and accumulate data.

Chart Ⅲ.4-1　Effective search half-width（m）

Floating debris	ALL	SS	S,M,L
FGN	3.1	3.1	3.1
FGF	93	15.7	97.4
FGO	4.3	4.2	4.4
EPS	30.7	15.7	68.7
FP	8.3	5.1	14.3
PBO	44.8	12.4	47.2
PC	10.2	6.2	21.8
PBA	9.6	6.6	10.8
G	10.3	10.7	9.4
M	34.3	31.5	39
W	18.7	15.7	19.3
UO	7.3	5.2	13.8
SW	3.1	3.1	3.7
DW	10.9	4	14.8
NO	3.9	3.8	4.6
UK	56.7	5.2	74.9

Chart Ⅲ.4-3　SHINYO maru　Effective search half-width（m）

Floating debris	ALL	SS	S,M,L
FGN	139.6	14.8	146.5
FGF	348.2	130.6	371.9
FGO	77.1	21.4	88.5
EPS	150.3	53.3	242.8
V	47.3	31.1	71.2
PB	67.7	66.5	68.4
PC	221	36.1	425.9
G	55.4	47.8	75.3
M	119	96.8	135.9
W	73.4	26.2	89.1
UO	60.3	48.3	66.9
SW	33.5	34.8	32
DW	60	25.1	85.5

Chart Ⅲ.4-3　UMITAKA maru　Effective search half-width（m）

Floating debris	ALL	SS	S,M,L
FGN	139.6	14.8	146.5
FGF	348.2	130.6	371.9
FGO	77.1	21.4	88.5
EPS	150.3	53.3	242.8
V	47.3	31.1	71.2
PB	67.7	66.5	68.4
PC	221	36.1	425.9
G	55.4	47.8	75.3
M	119	96.8	135.9
W	73.4	26.2	89.1
UO	60.3	48.3	66.9
SW	33.5	34.8	32
DW	60	25.1	85.5

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